Reporting Capabilities and Management of the DSN Energy Data Base

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The DSN Energy Data Base is a collection of computer files developed and maintained by DSN Engineering. The energy consumption data which it contains must be updated monthly and summarized and displayed in printed output as desired. The methods used to handle the data and perform these tasks are described in this article.

I. Introduction

The DSN Energy Data Base was implemented in 1976 at the request of the DSN Energy Conservation Project. Due to the significant amount of energy consumed by the DSN facilities and the increasingly important requirements for energy conservation, the Energy Data Base was designed to provide relevant and accessible information which would aid energy conservation engineering of the facilities. Reference 1 describes the initial design and details of the data base. However, as use of the Energy Data Base progressed, the need for a more efficient means of inputting monthly energy consumption data and for a method of presenting consumption data became apparent. Reorganization of some data base file groups and development of specialized computer programs were performed to achieve these needs.

II. General Description of the DSN Energy Data Base

The DSN Energy Data Base is a collection of computer files developed, maintained, and used to support the DSN engineers, station operators, designers, and managers in monitoring the progress of the Energy Conservation Project and providing engineering and environmental data for the evaluation of energy conservation measures. The DSN Energy Data Base contains energy consumption and engineering data for DSN facilities at Goldstone, Madrid, and Canberra. As described in Ref. 1, the functional objectives of the data base were to provide:

(1) A readily available source of technical and descriptive data.

(2) A central, standardized reference to augment engineering analysis and design.

(3) Information for effective energy management.

(4) A historical record for comparison of actual performance with project goals.

(5) Information for preparing NASA Energy Program Reports.

The Energy Data Base currently consists of four master files:

(1) Goldstone Energy Data (GED),

(2) Madrid Energy Data (MED),

(3) Canberra Energy Data (CED), and

(4) Goldstone Energy Audit Information (GEA).

The GED file is made up of elements containing Goldstone Deep Space Communications Complex (GDSCC) data on exterior lighting, building air conditioning systems, building utilities, interior occupancy, interior electrical equipment, interior lighting, building architecture, power plants, weather, programmatic changes, and all forms of energy consumption. It is the last category, in which data is being continuously updated, which requires development of a more efficient means of performing these updates. The MED file for the stations in Spain contains monthly energy consumption data for the Robledo site (DSS 61/63) and the Cebreros site (DSS 62), as well as energy audit data for the major buildings as modeled by the Energy Consumption Program (ECP). The ECP computer program was developed in 1977 by the DSN Engineering Section to model building loads and make detailed energy consumption analyses. The CED file for the stations in Australia contains data elements analogous to the MED file; its energy consumption data is for the Honeysuckle site (DSS 44) and the Tidbinbilla site (DSS 42/43). The latter two files were the subjects of initial effort to develop a means of reporting consumption data, since structure of these files is much more simple than that of the Goldstone consumption files. The GEA file contains ECP input data for building models at Goldstone. It was separated from GED because of its large size. The data base now physically resides on computer tape, and files are copied to disk when data is needed or when energy consumption files are to be updated.

III. Recent Modifications

The Madrid and Canberra MED and CED files were modified to facilitate the development of a reporting computer program which would extract, organize, display, and summarize data as required. The modifications began with consolidating separate file elements containing energy cost and consumption data into one element containing this data in a raw form. Thus, all energy consumption data now exists in one element for each DSS site, and summary data for either Madrid or Canberra is obtained as output from the reporting program.

The MED file element for the energy consumption at Cebreros (DSS 62) is shown in Table 1, as an example. Column headings were made brief for compactness. Of significance are data entries "NA" which indicate "not available" data and are recognized by the reporting program. Data consists of meter reading date, diesel fuel consumption, equivalent thermal energy of diesel fuel consumed, electrical energy produced, fuel cost per liter in Spanish and American currency, currency conversion rate, and hours of antenna support.

IV. Monthly Energy Consumption Reporting Techniques

It was desired to create a method of accessing, summarizing, and displaying data from both present and previous years on an annualized basis. Also, it was intended to automate the process of monthly reporting of purchased energy consumption for the DSN Energy Conservation Project management.

A computer program (called REPT) was developed which accomplishes these goals. REPT reads consumption period date, diesel fuel consumption, equivalent heat value, electrical production, fuel cost, and currency conversion data; it calculates unit energy cost, total monthly energy cost, and totals for the year or up to the most recent data point if the current year is being reported. This data is tabulated for each DSS site, and then summarized on a monthly and annual basis for the entire DSN Complex. A sample REPT output is shown in Table 2 for the Madrid Complex, for FY 1980 (September 1979 – August 1980). REPT was designed to be capable of reporting summaries for calendar years, fiscal years, or "energy years." An energy year is defined as the period July – June, which was the definition of a fiscal year prior to 1977.

The computer program logic was complicated by the fact that it had to read a line of data which represents one month's consumption, part of which would be numeric and part of which may be alphabetic in the form of a "NA" entry meaning "not available" data. This problem was handled by writing the program in FORTRAN and using FORTRAN's data conversion utilities. In REPT, data are read using the A-type format (alphanumeric) and the available (integer) data are converted from alphanumeric to computation-format binary integer. Any "not available" data which occurs on a data read triggers an appropriate flag which instructs following portions of the program to perform in a certain fashion. For example, if fuel consumption and fuel cost data are available but electrical production is not available, monthly energy cost can be calculated, but the unit energy cost cannot be calculated. Numerical data are then converted back to the alphanumeric format so that output formats can all be consistent, regardless of combinations of "not available" data.

In this fashion, the REPT program was designed to be completely general in terms of the data acceptance. It was decided not to use blanks or zeros for unavailable data (which would have permitted use of integers throughout the program) since zero is a valid data entry and blank is not specific enough.

Versions of REPT exist for use with both Madrid and Canberra data. A version will be developed soon to process the more abundant Goldstone data.

V. Data Entry Methods

Energy consumption data for an overseas Complex consists of one line of data for each site; a total of four sites supply data which are entered into the data base manually each month. Automation of this procedure would only offer the advantage of allowing a nonformatted input, which is not significant.

However, the Goldstone energy data consists of LPG consumption, diesel fuel consumption, water consumption, and purchased electrical consumption metered at various locations in the Complex. These data must be inserted in proper locations in each data file element, not added to the end of the element as with the overseas files. Therefore, updating the Goldstone data manually was a cumbersome task, and an interactive computer program had been developed to perform this task. This interactive program was first written in MBASIC, using canned sorting and merging subroutines to insert the new data.

The first trial program seemed to be quite inefficient since it took about 20 minutes elapsed time at the computer terminal and cost about $17 to process one month's data, which is about 70 data entries (data lines). It was decided to make a second trial and rewrite this program in FORTRAN, developing specialized subroutines to sort and merge the data. The second program (called ECD-UP) takes about 1 minute elapsed time and costs about $3 to process one month's data.

Since specialized sorting and merging techniques were developed for ECD-UP, a block diagram and a functional description of the salient features of this program are presented in Appendix A.

VI. Future Development

Programmatic changes in equipment and operating procedures are of high interest since energy consumption reporting techniques used by DSN Engineering take these changes into account. It is planned to develop an access program to process programmatic data.

Efforts are underway to couple the REPT program with advanced in-house graphics equipment, using a Hewlett-Packard graphics terminal and plotter to produce management reports, pie-charts, bar-charts and various plots which are used in monthly reporting to NASA.

In addition to the above, an expansion and a revision of the REPT program will be developed to process Goldstone energy consumption data in a fashion similar to the efforts made for overseas energy data.

Future development of the energy data base will be affected by new functional requirements of the Technical Facilities Controller (TFC) or the Configuration Control Assembly (CCA) Subsystem. Both may contain elements of the DSN Energy Data Base. However, since details concerning implementation of these systems are still under development, the Energy Data Base is being developed to best suit the current needs of engineers and management, with attention given to the development of the TFC and CCA.

VII. Summary

The reorganization and automation of data processing of the DSN Energy Data Base has led to reduced effort, low cost, and better handling in working with the data. It is expected that future enhancement of automation will increase the efficiency of data base operations.

Reference

1. Cole, E. R., Herrera, L. O., and Lascu, D. M., "DSN Energy Data Base Preliminary Design," in *The Deep Space Network Progress Report 42-51*, pp. 167-175, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1979.

Table 1. Energy data base file element "MED.ECM1502"

ECM/502 CEBREROS(DSS62) CONSUMPTION*

MO	YR	DATE	DIESEL (LITERS)	EQUIV (MWHT)	ELECT PROD (KWHE)	COST/ LITER PTS	COST/ LITER ($US)	PTS/$US	SUPPORT (HOURS)
07	73	0801	85000	913	NA	NA	NA	NA	170
08	73	0901	90000	966	NA	NA	NA	NA	210
09	73	1001	85000	913	NA	NA	NA	NA	230
10	73	1101	83000	891	NA	NA	NA	NA	180
11	73	1201	93000	999	NA	NA	NA	NA	420
07	79	0801	50975	543	172000	15	.23	66	563
08	79	0901	46966	504	NA	15	.23	66	426
09	79	1001	49515	532	154000	15	.23	66	429
10	79	1101	48387	519	144000	15	.23	66	422
11	79	1201	42700	458	147000	15	.23	66	484
12	79	0101	45124	484	153000	15	.23	66	580
01	80	0201	47704	512	164000	19	.29	66	590
02	80	0301	44446	477	152000	19	.29	66	585
03	80	0401	44995	483	154000	19	.27	70	555
04	80	0501	35232	378	112000	19	.27	71	214
05	80	0601	37650	404	124000	19	.27	71	288
06	80	0701	44322	476	149000	19	.27	70	504
07	80	0801	46078	494	153000	22	.27	71	536
08	80	0901	46877	503	159000	22	.27	71	541
09	80	1001	43396	465	144000	22	.31	71	482
10	80	1101	41796	449	138000	22	.29	75	413
11	80	1201	40477	435	132000	22	.29	75	326

* The period 10-79 to 9-80 is shown in Table 2 as REPT output.

Table 2. REPT output

ENERGY CONSUMPTION SUMMARY FOR MADRID DEEP SPACE STATIONS **
FOR FY 80

ROBLEDO SITE (DSS 61/63)

MONTH	DIESEL FUEL CONSUMPTION (LITERS)	EQUIV HEAT VALUE * (MWHT)	ELECTRICAL PRODUCTION (KWHE)	FUEL COST /LITER PTS	FUEL COST /LITER ($US)	CURRENCY CONVERS. PTS/$US	ENERGY COST /UNIT ($/KWHE)	MONTHLY ENERGY COST ($US)
OCT	210273	2258	618289	15	.23	66	.0782	48362
NOV	202019	2169	625454	15	.23	66	.0743	46464
DEC	216906	2329	662987	15	.23	66	.0752	49888
JAN	206341	2215	624133	19	.29	66	.0959	59838
FEB	196213	2207	578343	19	.29	66	.0984	56901
MAR	202726	2177	601600	19	.27	70	.0910	54736
APR	210883	2271	640000	18	.25	71	.0824	52720
MAY	196555	2110	591570	18	.25	71	.0831	49138
JUN	223823	2403	674482	22	.31	70	.1029	69385
JUL	239613	2573	721600	22	.31	71	.1029	74280
AUG	243793	2618	741600	22	.27	71	.0888	65824
SEP	231389	2484	716000	22	.31	71	.1002	71730
TOTAL	2580534	27814	7796058					699266

CEBREROS SITE (DSS 62)

MONTH	DIESEL FUEL CONSUMPTION (LITERS)	EQUIV HEAT VALUE * (MWHT)	ELECTRICAL PRODUCTION (KWHE)	FUEL COST /LITER PTS	FUEL COST /LITER ($US)	CURRENCY CONVERS. PTS/$US	ENERGY COST /UNIT ($/KWHE)	MONTHLY ENERGY COST ($US)
OCT	48387	519	144000	15	.23	66	.0773	11129
NOV	42700	458	147000	15	.23	66	.0668	9820
DEC	45124	484	153000	15	.23	66	.0678	10378
JAN	47704	512	164000	19	.29	66	.0844	13834
FEB	44446	477	152000	19	.29	66	.0848	12889
MAR	44995	483	154000	19	.27	70	.0789	12148
APR	35232	378	112000	19	.27	71	.0849	9512
MAY	37650	404	124000	19	.27	71	.0820	10165
JUN	44322	476	149000	19	.27	70	.0803	11966
JUL	46078	494	153000	22	.27	71	.0813	12441
AUG	46877	503	159000	22	.27	71	.0796	12656
SEP	43396	465	144000	22	.31	71	.0934	13452
TOTAL	526911	5653	1755000					140390

MADRID COMPLEX TOTALS

MONTH	DIESEL FUEL CONSUMPTION (LITERS)	EQUIV HEAT VALUE (MWHT)	ELECTRICAL PRODUCTION (KWHE)	MONTHLY ENERGY COST ($US)
JAN	258660	2777	762289	59491
FEB	244719	2627	772454	56285
MAR	262030	2813	815987	60266
APR	254045	2727	788133	73673
MAY	240659	2684	730343	69791
JUN	247721	2660	755600	66884
JUL	246115	2649	752000	62233
AUG	234205	2514	715570	59304
SEP	268145	2879	823482	81352
OCT	285691	3067	874600	86721
NOV	290670	3121	900600	78480
DEC	274785	2949	860000	85183
TOTAL	3107445	33467	9551058	839663

* HEATING VALUE OF FUEL USED IS 10.74 KWHT/LITER.
** THIS REPORT IS BASED ON MONTHLY INFO SUBMITTED BY OVERSEAS COMPLEX OPERATIONS

Appendix A

ECD-UP Program Description

The ECD-UP program updated Goldstone DSCC energy consumption file elements on a monthly basis by reading update data punched on computer cards. The existing data to be updated are contained on four computer file elements consisting of LPG, diesel fuel, water, and electrical consumption. ECD-UP first reads the updated data from the cards and inserts it into a single working array. This action is performed in the READIN subroutine (see Fig. A-1).

The SORTER subroutine is then called to sort and order the data in the array according to the four sort keys, listed in order of highest to lowest priority: station number, meter number, year, and date. The data array should be thought of as a matrix, with each row representing a line of data taken from a data card. A line of data contains a month's consumption data for a particular station, meter, year and date. This subroutine uses the "bubble sort" technique by indexing through the array line-by-line, comparing the sort keys of each line with the next line, and exchanging two lines if they are out of sequence. Several passes are made through the data until no exchanges are made, indicating that the data are ordered properly. For example, if three consecutive data lines contain the same site number, SORTER will then look at the meter numbers and decide whether or not to exchange data lines, placing the line with the lowest numbered meter first.

The DIVIDER subroutine, called next, separates the updated data into four arrays corresponding to LPG, diesel fuel, water, or electrical consumption. The meter number is used to determine into which category each data line should be placed.

The MERGER subroutine then inserts the updated data into the existing data elements. It does this by reading the existing data, line-by-line, and comparing each line with the current line in the appropriate updated data array using the sort keys. If the updated data line should be inserted, it is written onto the new version of the data base file element; otherwise, the existing data line is written onto the new version of the element. The program reads through the existing data, in this fashion, indexing through the updated data, as it is inserted into the existing data.

When the end of either type of data is encountered, control passes to the FINFIL or FINAR subroutines, which write the remaining data onto the new file element and, finally, replace the old file element with the new element.

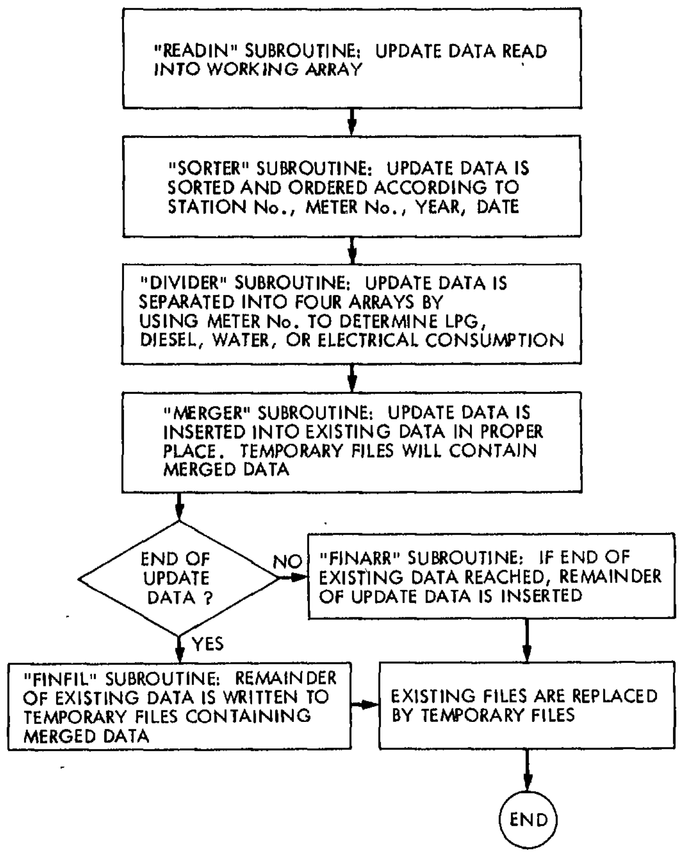

Fig. A-1. ECD-UP program block diagram